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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Mark J. Miller et al.

Application No.: 09/531,996

Filed: March 20, 2000

For: METHOD AND APPARATUS FOR MULTIPLE ACCESS OVER A COMMUNICATION CHANNEL

Examiner: Curtis B. Odom

Technology Center/ Art Unit: 2634

DECLARATION
under
37 CFR § 1.131

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

We, the undersigned inventors, declare as follows:

1. We are the co-inventors of the above-captioned patent application.

2. We understand that in an Office Action mailed June 15, 2005, certain of the claims have been rejected as unpatentable over Kondo, U.S. Patent No. 6,480,523, filed March 2, 1999.

3. Prior to March 2, 1999, we conceived of the invention disclosed in the above application and recited in the relevant claims of the application, as evidenced by the following:

   - Exhibit A is a copy of an internal document entitled "CDMA Back Channel," that was created on May 27, 1998 and last modified on June 5, 1998.

   - Exhibit B is output from a directory listing in a WinZip-type file in which the internal document is stored. The directory listing shows a "last modified" date of the internal document to be June 5, 1998.

4. Section 2.7 of the internal document (Exhibit A) states that "Many transmitters will use the same CDMA code." *Page 11, second line.*

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5. On August 13, 1999, U.S. Provisional Application No. 60/148,925 was filed.

6. We exercised due diligence in reducing the invention to practice during a period of time that spans at least from June 5, 1998 to March 20, 2000 when we filed the above-referenced non-provisional application.

   a. During the time between June 5, 1998 and August 13, 1999, we maintained a continued effort to further develop the invention. On August 13, 1999 a provisional application was filed.

   b. During the time between August 13, 1999 and March 20, 2000, we maintained a continued effort to further develop the invention. On March 20, 2000, the above application was filed, and is a non-provisional application of the August 13 provisional application.

7. We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that *willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.*

Dated 10/26/2005 Mark J. Miller

Dated 11/4/2005 Mark D. Dankberg

Dated 11/4/2005 Charles N. Pateros

Exhibit A

1. Overview

The back channel for the Cyberstar C2 system should be a robust link which has the flexibility to handle to following services efficiently

- Frequent short messages commonly used to provide forward link packet acknowledgment or request downloads.
- Large messages to support file transfer and uploads
- Stream services to support voice or very large file transfers

In this white paper we describe a CDMA waveform which provides a flexible and efficient back channel for use with the Cyberstar C2 system. The proposed back channel works well with short messages long messages and stream services. The back channel is provided using data rates from 8 kbps up to 128 kbps, a 1 Watt Power amplifier and a 1.2 meter dish. The CDMA approach offers many unique advantages as compared to a TDMA slotted Aloha approach:

- Aggregate Capacity: Capacity is measured by the total average throughput (bits per second) normalized by the bandwidth required. Our proposed CDMA approach can achieve a capacity up about 0.34bps/Hz and will typically be better than a slotted Aloha TDMA approach.
- Robustness to Impulse Noise on forward channel. Momentary interruptions on the forward channel will cause many active users to send back "No Acknowledgments" (NAK's) on the packets were missed due to the momentary interruption on the forward link. All these NAK's will be sent back at approximately the same time. Our CDMA approach is much more robust to impulse traffic than a slotted Aloha TDMA approach.
- Independence of the backward and forward channel: An ACK/NAK protocol on the back channel traffic is not required, thus the traffic on the back channel does not impact forward channel throughput.
- Message reliability: The message reliability for our CDMA system does not degrade as the back channel capacity is increased. A slotted Aloha TDMA system does not have this characteristic.
- Simplicity: ACK/NAK protocols and reservations protocols for stream services are not needed. Accordingly there is no need for any mode switches from slotted Aloha mode to dedicated stream mode.

Section II of this paper provides a technical description of the back channel and quantifies some of the performance characteristics of the channel. In section III, a candidate course of action is proposed between ViaSat and Cyberstar which allows the development of a CDMA back channel system in a timely manner.

2. Technical Description

Pure FDMA or TDMA (or hybrids thereof), where a single time or frequency slot, is continually reserved for each active (logged in) user of the network is a very inefficient networking approach for the Cyberstar back channel. That is because the majority of time, individual subscribers are not transmitting, hence the majority of the time/frequency slots are unused. An Aloha scheme, where a users transmits his data whenever he has data to transmit, much more efficient. The only problem with Aloha and slotted Aloha, is that whenever two (or more) packets overlap in time and frequency, a collision occurs and all packets are lost. All packets must be re-transmitted after a random backoff to avoid another collision. Although this approach is much more efficient than a pure TDMA of FDMA scheme, it can still be improved by combining it with CDMA to reduce the dramatically impact of collisions. The resulting approach, sometimes referred to as spread Aloha, is the core of our approach to the Cyberstar back channel.

The following paragraphs provide a technical description and performance analysis for out CDMA back channel approach. To better depict the benefits of our CDMA approach, the performance of our CDMA approach is compared to that of a slotted Aloha system.

2.1 Waveform Description and Link Analysis

Table 2-1 summarizes the parameters for a candidate back channel Direct Sequence CDMA waveform. This waveform is proposed for use on a 27 MHz transponder using (Paired Carrier Multiple Access) PCMA to enable the back channel to exist beneath the forward channel, hence eliminating the need for additional bandwidth to realize the back channel.

Table 2-1. Back Channel Waveform Parameters

Parameter	Value
Data Rate	8.0, 16, 32, 64, or 128
Chip Rate	23.04 MHz
Modulation	BPSK
Filtering	Square Root Raise Cosine, α=1.2
FEC	r=1/3, Concatenated Convolutional Coding
Interleaving Delay	≤1024 bits end to end
Eb/No required for BER=10^{-5}	3.0 dB

It should be noted that our waveform does not require PCMA and can be implemented on a separate transponder. In which case, it may desirable to reduce the chip rate so that only a fraction of the entire transponder would be needed. This reduction can be made at the expense of capacity.

Table 2-2 shows a link budget using a 1.0 Watt power amplifier at the transmitter, the Telstar 5 satellite, and a NOC terminal with a G/T of 35.9 dB/°K. At the largest data rate, 128 kbps, there is 6.8 dB of excess margin.

Table 2-2. Link Analysis for Back Channel

Item	Value	Notes
HPA Output, dBW	0.00	1.0 Watts at full power
Waveguide Loss, dB	0.50	
Antenna Gain, dBi	43.45	1.2 Meter Dish
EIRP, dBW	42.95	
Frequency, GHz	14.14	
Path Loss, dB	207.01	
Pointing Loss, dB	1.00	
Misc Propogation Losses, dB	0.62	
Sat. G/T, dB/°K	1.00	Telstar 5
Uplink C/No, dB-Hz	63.92	
Uplink C/ASI density, dB-Hz	71.90	
Uplink C/XPI density, dB-Hz	77.70	
Effective C/No,dB-Hz	**63.12**	
Input Flux Density, dBW/m^2	-121.23	
Saturation Flux Density, dBW/m^2	-77.40	Telstar 5
Per Carrier Input backoff, dB	43.83	
Output Backoff total, dB	3.80	
Input Backoff total, dB	9.30	
Tx EIRP at Saturation, dBW	48.00	Telstar 5
Tx EIRP per Carrier, dBW	9.67	
Frequency, GHz	11.84	
Path Loss, dB	205.47	
Pointing Loss, dB	0.20	
Misc Propogation Losses, dB	0.39	
Rx G/T, dB/°K	35.85	7 Meter Dish
Downlink C/No, dB-Hz	68.06	
Downlink C/ASI density, dB-Hz	82.70	
Downlink C/XPI density, dB-Hz	82.70	
Effective C/No,dB-Hz	**67.77**	
System Margin, dB	1.00	
End-End C/No, dB-Hz	**60.84**	
Data Rate, kbps	128.00	
Eb/No Available, dB	9.77	
Eb/No Required, dB	3.00	
Excess Margin, dB	**6.77**	

The selection of the data rate, in part, is made by the subscriber. One approach has the subscriber paying for the use of a particular data rate. For example a subscriber may select a 128 kbps rate, as opposed to a 32 kbps rate, but there would be a larger per pack charge to his account. The transmitter would use the data rate selected by the subscriber for all burst transmissions where link conditions support that rate. In link conditions don't support that rate, due to excessive rain fades combined with large network loads, a lower data rate will be used to send the packets.

All packets will consist of a header which identifies the data rate used for the remainder if the packet. The header is always transmitted at the most robust 8.0 kbps. This technique eliminates data rate pre-coordination requirements between the transmitter and receiver.

In all transmissions, the actual transmitted power will be dynamically adjusted in proportion to the data rate. This maximizes the both the back channel capacity and the number of simultaneous access.

2.2 Capacity

In spread spectrum systems, interface rejection is characterized by the amplitude of the interfering signal that can be tolerated with respect to the amplitude of the user signal. They are related by the following,

$$\frac{I}{S}=\frac{R_c/R_b}{E_b/N_o} \tag{2-1}$$

where R_c is the chipping rate of the spread spectrum system, R_b is the information burst rate, and E_b/N_o is the energy per bit to noise spectral density required to maintain a specified Bit Error Rate. In (2-1) the term I represents the power of all other signal when measure at receiver input. The term S represents the power of the desired signal when measured at the same point. For each transmitter, the power transmitted will be proportional to the burst information rate being used. Furthermore, the power level and/or burst rate will be adjusted to accommodate any rain fade losses (refer to section 2.5) such that the power of each back channel signal, when measured at the satellite input, will be proportional to the burst information rate. Hence, at the hub receiver, the received signal power level, for the signal to be demodulated, is kR_b, and the received power for all other multiple access signals is kR_{b_i}, where k is a constant of proportionality. The total power of all other multiple access signals is $I=\sum kR_{b_i}$. Using (2-1) one can determine the total throughput of the network[1],

$$\sum R_{b_i}=\frac{R_c}{E_b/I_o} \tag{2-2}$$

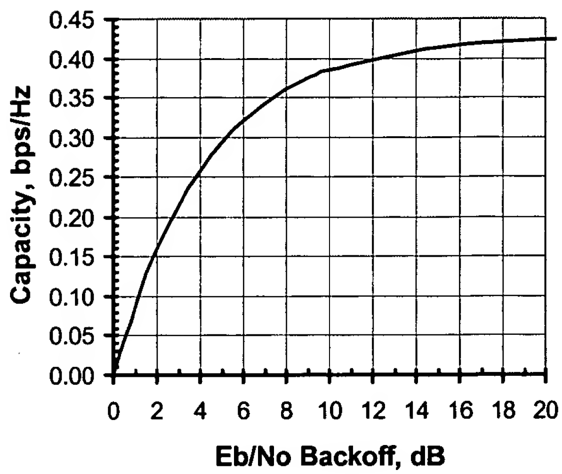
where, I_o ,has been used instead of N_o to indicate an interference density instead of a thermal noise density. The maximum value of this total throughput, which occurs at the minimum value of E_b/I_o, is the network capacity. The CDMA code chipping rate, R_c, is generally a significant portion of the allowed bandwidth. R_c can be expressed as W/α, where W is the allocated bandwidth to the back channel network and α is a factor (≥ 1). For our candidate selection of chip rate, 23.04 MHz and bandwidth (27 MHz), $\alpha = 1.17$. Normalizing 2-2 by the allocated bandwidth, W results in the normalized capacity, in bps/Hz

$$\eta_{CDMA}=\frac{1}{\alpha\, E_b/I_o} \tag{2-3}$$

The value for E_b/I_o can bet determined from the performance of the selected modulation and the link budget. The effective E_b/N_o (due to the sum of thermal noise and multiple access interference) is related to the actual E_b/N_o (due to thermal noise) by,

[1] Actually this is only the sum the data rates of all signals except the one of interest. An exact expression would have the term R_b added on to both sides. Since the rate of any one individual user is much smaller than the aggregate sum, when operating at capacity, the equation shown is accurate.

$$\frac{1}{\left(E_b / N_o\right)_{eff}} = \frac{1}{\left(E_b / N_o\right)} + \frac{1}{\left(E_b / I_o\right)} \tag{2-4}$$



The term $(E_b/N_o)_{eff}$ is the SNR per bit needed by the selected modulation and coding to meet a specified BER. This is a very important parameter in maximizing the capacity. The smaller this value is made (by the selection of modulation and coding) the larger the resulting capacity. For our selected modulation and coding, the $(E_b/N_o)_{eff}$ is 3 dB for a BER of 10^{-5}, and includes an implementation margin of 1 dB. The term E_b/N_o in Eq. 2-4 represents the actual E_b/N_o over the link due to the thermal noise only. Referring to Table 2-2, this level is about 9.8 (6.8 backed off from receiver specified level). Thus, the term E_b/I_o is about 4.0 dB. Combining this with the value of α yields a normalized capacity for CDMA of 0.34 bps/Hz. The figure to the side shows the normalized capacity for CDMA as a function of E_b/N_o backoff level. Note that by reducing the maximum data rate, the E_b/N_o backoff is increased, resulting more network capacity and conversely, increasing the maximum data rate decreases E_b/N_o backoff and thus reduces capacity[2].

The maximum capacity (unnormalized) of the back channel is $W\eta_{CDMA}$ or about 9.1 Mbps. At any instant of, the total throughput of the network should not exceed this value, or the BER of all users will not be guaranteed to be less than 10^{-5}. This value is equivalent to 1141 eight kbps transmissions. Equivalently, the total aggregate throughput can be expressed as 71 x 128 kbps transmissions. In general, any mix of transmissions can be supported, as long of the sum of all the data rates is less than 9.1 Mbps.

We compare the capacity of the CDMA approach with that of a slotted Aloha TDMA or TDMA/FDMA hybrid. Consider a slotted Aloha approach using a modulation of QPSK with r=1/2 Forward Error Correction (FEC) coding. This waveform achieves one bit per symbol. Now, using the same bandwidth usage efficiency factor, α, as before results in an normalized average throughput of 1/α. Now we must take into account the efficiency of a slotted Aloha system. This is a function of the network load, and obtains a maximum value of .37. But when this efficiency is obtained, the probability of a transmitting a packet without a collision is also .37. This means that 63% of the packets will need to be re-transmitted after a random backoff. And 63% of the re-transmitted packets must again be re-transmitted after a random backoff. And so on. Since the cost of each re-transmission is the timeout delay (the time a transmitter must wait, without receive a successful packet acknowledgment, before it decides that that packet was

[2] For example, the E_b/N_o backoff can be increased by 3 dB by limiting the maximum data rate to 64 kbps and using the full 1.0 Watt PA power for this data rate. All other transmissions should use a transmit power proportional to this amount, which results in an amount 3 dB larger than the case using a maximum data rate of 128 kbps. This increases the E_b/N_o backoff for all links.

not received) plus an approximate 250 mSec delay, anything other than periodic collisions adversely affect network responsiveness. It is not felt that a collision probability of 63% will yield acceptable network responsiveness. The slotted Aloha efficiency, as a function of the successful packet probability, is $-\rho\ln(\rho)$ where ρ is the probability of no collision when sending a packet. A minimum interesting value of ρ is probably 0.90, and more likely values are 0.95 to 0.99. The minimum value of .90 corresponds to a slotted Aloha efficiency of 0.095. This results in an normalized capacity for slotted Aloha of $\eta_{slottedAloha} = 0.095/\alpha$. Using the previous value of α, results in a normalized throughput of 0.081, significantly less than the value of 0.39 obtained by our CDMA approach.

The last interesting comparison is with a system that uses slotted Aloha for short bursts and reservation channels for stream services such as voice. Assume that 50% of the network is allocated to voice stream and the balance is allocated to slotted Aloha access. The slotted aloha has an efficiency of 0.095 and the voice stream operate at an efficiency of 0.4 (on the average, a person is talking about 40% of the time). The overall normalize throughput is 0.248/α, or 0.211 bps/Hz. This is still less than the value we obtain with our CDMA approach.

2.3 Robustness

Since a CDMA approach is can operate with collisions, it is very robust against impulse traffic. Such impulse traffic may occur when there is a momentary outage of the forward channel. In such a case, a large quantity of approximately simultaneous NAK's, may occur on the back channel. Given a back channel capacity of 9.1 Mbps and all users operating at 128 kbps, up to 71 simultaneous NAK's could be supported. In addition a random backoff may be used to help in the situation where there is a larger number of simultaneous NAK's.

The physical layer of the network is also very robust to traffic load. At minimal or no load, the network operates at maximum responsiveness. As the network load increases, the responsiveness, due to the physical layer effects, does not slow down at all. The time it takes to provide a file transfer is also not affected. *This trend continues all the way up until the network capacity is reached.* When the network capacity is exceeded, the power control protocol (refer to section 2.5) will automatically reduce the network load (reduce the data rates) to a level below capacity. This will increase the time it takes to transfer files or any other data transfer that is occurring at a rate other than the minimum data rate. The automatic load reduction of the network provides a graceful degradation as load starts to exceed capacity.

Contrast this robustness to a slotted Aloha approach, where as the load increases the number or collisions and probability of a collision increases. Since each collision requires a re-transmission, the responsiveness of the network will decrease well before the load reaches capacity.

2.4 Simplicity

The operational simplicity of the CDMA approach is apparent from it basic "transmit when desired" protocol. As a result, the CDMA back channel has many advantages over a slotted Aloha multi channel TDMA approach. The advantages are summarized in the table below. Due

to the frequency collisions in a slotted Aloha system, all successful transmissions must be immediately acknowledged. This requires more overhead on the forward link to implement the acknowledgments.

Item	CDMA	Slotted Aloha
ACK/NAK on forward packets	Must NAK missed forward packets	Must NAK missed forward packets
ACK/NAK on service requests and forward channel NAK's	Not needed	Must ACK all good packets
ACK/NAK on data stream packets	Must NAK missed packets	Must NAK missed packets
ACK/NAK on voice packets	Not needed	Not needed
Stream Reservation Requests	Not Needed	Needed to reserve FDMA channels for data and voice streams
Operating Modes	Only 1 needed: Random Access	2 Needed: Random access and reservation access
Slot Synchronization	Not needed	Required

2.5 Power Control

To minimize the multiple access interference (MAI) and to provide network robustness rain fades, a power control scheme is used to appropriately balance the powers of all the signals when seen at the NOC receiver. The discussion is started with a description on how uplink and downlink rain fades affect the network. Then a description of the two potiential power control system is provided as well as the system impact to uplink and downlink rain fades. Finally the benefits of the power control system are heuristically quantified by comparing the system operation to a fictitious system that doesn't use dynamic power control.

<u>Impact of Rain Fades on CDMA Back Channel</u>

Consider a rain fade on the uplink of an individual subscriber. In this case the subscriber will experience increased MAI since the power of his signal at the transponder has been decreased but the power of all other subscriber signals has not been reduced. If the network load is not too close to capacity, then this increased MAI is not going to affect him. On the other hand, if the network load is close to capacity, this user will loses his ability to communication over the back channel.

The affects of a downlink fade are to reduce received signal level of all subscriber transmissions at the NOC. The MAI has not changed since all signal are reduced equivalently. However, the E_b/N_o backoff on all subscribers has been decreased. If the network load is not close to capacity, this will have no affect on the network. If the network load is close to capacity, or the fade is extremely deep (deeper than the 6.8 dB excess margin in Table 2-2) than all the back channel links will be lost.

<u>Power Control Approach I</u>

In the absence of rain (or other propagation loss) on either the uplink or downlink, the powers are already balanced at the NOC receiver by having each user set their EIRP in proportion to their data rate. Now, consider a rain event on the back channel downlink. The powers are still balanced at the NOC receiver since the rain fade applies equally to all downlinks. However, the E_b/N_o for all links is degraded. The reduced E_b/N_o combined with the MAI (E_b/I_o) result in a reduced effective E_b/N_o. This reduction may cause the links to be lost. To prevent this from

happening, the NOC shall estimate the downlink fade. When it detects that the downlink fade is excessive, it shall issue a command that causes everyone to decrease their data rate by a factor of 2 without decreasing their EIRP. When transmitting at the lowest data rate, 8kbps, the transmitter shall increase it's EIRP by 3 dB. The NOC will determine downlink rain fade by monitoring the received C/N_o on the return channels as well as the C/N_o it receives on it's own broadcast.

Now, consider rain the uplink of transmitter *i*. In order to keep the powers balanced, transmitter *i* must know increase his power by an amount to compensate for the uplink rain loss. If he has insufficient PA size to increase his power, he must reduce his data rate an then adjust his transmit power accordingly. User *i* can determine his uplink rain fade, to a first approximation, by monitoring the receive signal quality of the forward link. This assume the forward link EIRP is pre-adjusted for any uplink rain fade. This will be a NOC responsibility. Any fine tuning of the power selection (or data rate selection) can be performed by the NOC assigning a power/data rate correction to user *i* based upon the signal quality of user *i*'s transmission as observed by the NOC.

Power Control Approach II

In the absence of either uplink or downlink fades, the powers are already balanced at the NOC receiver by having all users transmit in proportion to their data rate. The power control approach will have each user reduce his data rate by a factor of two an any time his link quality is excessively degraded. If the data rate is already at the minimum value of 8 kbps, then the user may increase his power in small increments until the link quality is sufficient. Each user will determine this on his own by either

a) receiving an abnormally high amount of NAQ's to his transmissions (such as file transfer transmissions) or

b) observing that an abnormally high amount of his requests (such as URL request, NAK of the forward link packets, or other request that don't require the NOC to provide a positive ACK or NAK response) are ignored (timed out).

This power control approach is effective since it is a closed loop approach. It is also very simple because it doesn't require any action for the NOC and it doesn't require precise measurements of C/N_o.

In the presence of an uplink rain fade for user *i*, his power will be unbalanced resulting in an E_b/I_o which is lower than that of everyone else. His E_b/N_o will also be reduced due to the lower signal level at the satellite. If the network is operating at or near capacity, or the fade is deep enough to significantly reduce his E_b/N_o, this link will become non-functional. At this point, user *i* will detect the problem by either a) or b) above (or both) and compensate by reducing the data rate or increasing the transmit power. This is the desired correction to the uplink rain fade.

In the presence of downlink rain fades, the powers are still balanced at the receiver since the fade affects all CDMA downlinks equally. The fade will decrease the E_b/N_o for all users. This decreases the capacity since the E_b/N_o backoff (the difference between the actual E_b/N_o and the

E_b/N_o required by the waveform is decreased. The lost capacity of the system can only be restored by reducing the maximum data rate on the return channel and increasing the power of all other transmissions. The power control approach does this exactly this! It is accomplished by i) all transmitters except the lowest data rate transmitters will reduce the data rate without reducing their EIRP and ii) the lowest data rate users will increase their EIRP and maintain the same data rate.

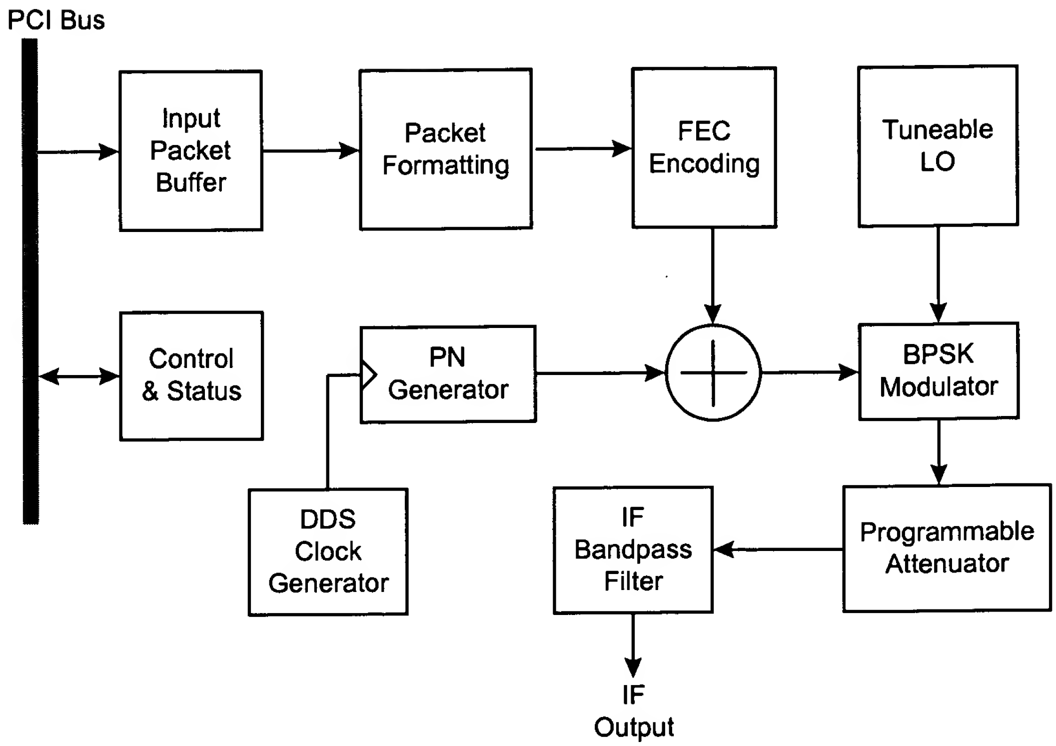
The drawback of this approach is that the potential for the network to become unstable, under certain loading conditions, when it is loaded beyond capacity. For example, consider a case where the network is fully loaded using only 8 kbps voice transmissions. Now, increase the network load. All links will experience an unacceptable amount of MAI (E_b/I_o) and attempt to increase their EIRP. Since all users increase their EIRP, the MAI does not decrease, and users continue to increase their EIRP. Ultimately, the satellite becomes fully saturated and the MAI problem does not go away. Note that this scenario does not occur when the network is fully loaded with higher data rate users. As loading increases beyond capacity, the data rates are reduced which reduces the network load.

As aforementioned scenario which results in a "power race" can be avoided by having the NOC issue a "halt power adjustment" command. In this mode, the only form of power control transmitters are allowed to implement is a reduction of data rate, which is a highly desired feature since it reduces network load. Reduction of network load is the only thing that can be done when the network is overloaded.

<u>No Power Control</u>
If no scheme is going to be implemented to balance the powers by either data rate adjustment or EIRP adjustments, large amount of margin must be built into the system to accommodate rain fades to yield a desired availability. This will result in large reductions in maximum data rate that can be used and network capacity. For example, consider that it is deemed that 6 dB of link margin is required to yield an acceptable link availability. Then 6 dB of margin must be built into both the uplink and the downlink. Since the back channel links are more uplink limited, this margin will decrease the maximum data rate by about 6.4 (as opposed to 16 if the channel was completely downlink limited). In addition, the capacity of the network must be reduced by 6 dB to accommodate uplink rain fades on an individual user. The net effect for this example would be to reduce the maximum data rate from 128 kbps to about 20 kbps and to reduce the back channel capacity from 9.1 Mbps (0.34 bps /Hz) to 2.3 Mbps (0.08 bps/Hz). The affects would obviously be worse at Ka band where the rain fades are deeper.

2.6 Transmitter Architecture
The back channel system is designed to result in a low cost transmit card to be used on the subscriber end. This circuit card interfaces with the PCI bus within the subscriber's computer and provides an IF output to the outdoor unit. A block diagram of the transmit card is shown in Figure 2-1.

Figure 2-1. Transmitter Block Diagram



The key features of the transmit card are itemized below,

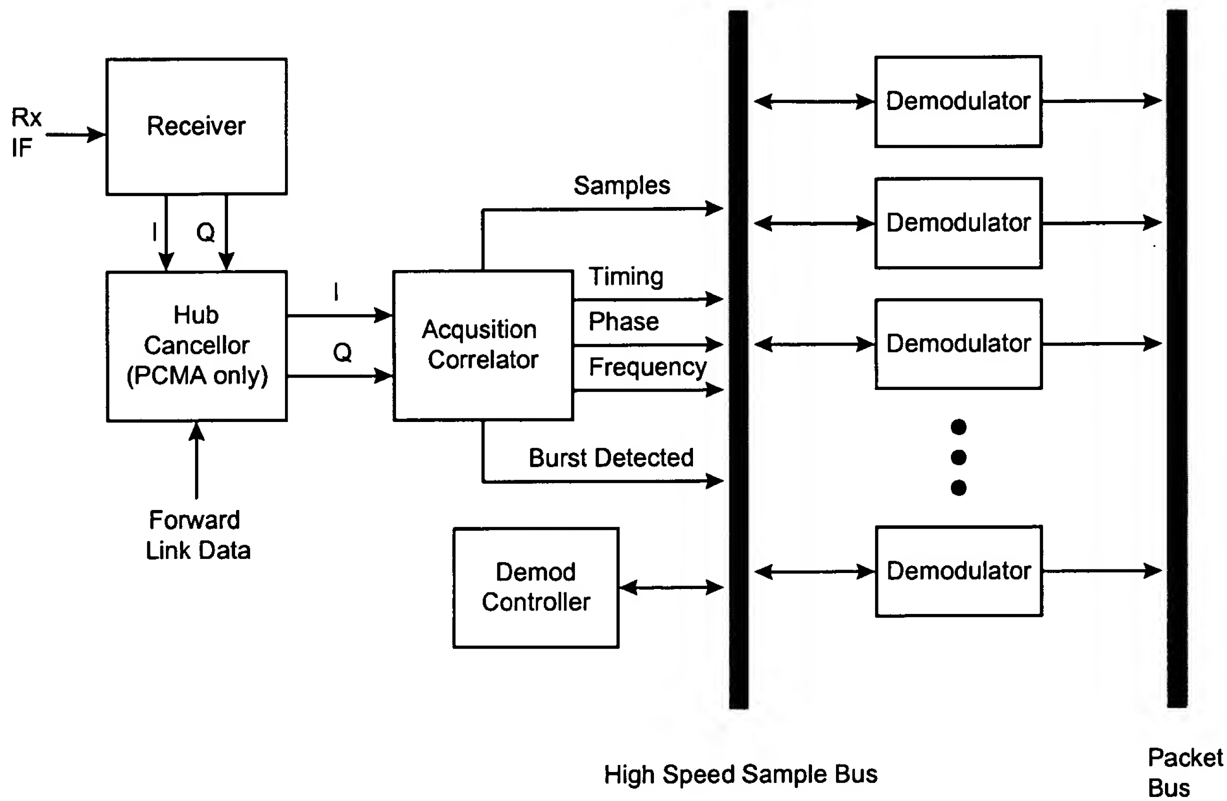
- BPSK modulator using Square Root Raised Cosine (SRRC) filtering for spectral containment.
- A DDS based generation of the PN clock to enable selectable Chip rate from 3.072 MHz to 26.112 MHz in step sizes of 768 kHz. The data rate is an integer divide down from the PN clock. The PN clock rate options will support the data rates of 8, 16, 32, 64, and 128 kbps.
- A tuneable LO for the bi-phase modulator to allow center frequency selection over the IF band in increments of 1 MHz.
- A Programmable attenuator to enable dynamic output power adjustment in 2 dB increments
- A control interface to the PCI Bus which enables the modulator to be completely configured (Chip rate, Tx frequency, output power level) by external software

2.7 Receiver Architecture

The receiver architecture is shown in Figure 2-2 below. It consist of four main blocks. A single demodulator card is needed for each simultaneous transmission, where all of the others functions can support simultaneous transmissions. Only one receiver card and one Hub cancellor are

needed for each transponder. Only one acquisition correlator is needed for each CDMA code used on a transponder. Many transmitters will use the same CDMA code. We estimate that only about 10 CDMA codes are needed to support the full capacity offered by the CDMA approach. Whereas hundreds of demodulators may be required, depending on the traffic mix, to support full capacity.

Figure 2-2. Hub Receiver Architecture



Each of the modules in figure in a VME module that plugs into a VME backplane. A brief description of each of the modules follows.

<u>Receiver</u>
This module provides,

1) Downconversion from IF to baseband. Tuning steps of the receiver are 1 MHz increments.

2) IF Gain and Automatic Gain Control

3) I/Q phase splitting and A/D conversion

<u>Hub Cancellor</u>

This module is used if Paired Carrier Multiple Access (PCMA) techniques are used to provide frequency re-use for the back channel. In which case the forward link and the back channel occupy the same frequencies at the same time. The hub cancellor module is used to subtract out the forward link from the composite receive signal. If PCMA is not used, the hub canceller module is not required.

Acquisition Correlator

This module provides the following functions,

- Matched filtering. The filters are matched to the CDMA chip rate and the SRRC filtering of the BPSK signal.

- Correlation. This module provides a correlation of the received signal with start of the CDMA code. This correlation is performed on a sample by sample basis. When a burst arrives, the correlation threshold is exceeded and the detect burst line becomes active

- Parameter Estimates. Phase, frequency, and fine timing estimates are generated within this module. Coarse timing is provided by the activation of the burst detect line.

Once a correlation is found, the remaining processing of that packet is handed off to one of the demodulator cards. The acquisition correlator than continues it's correlation process to perform burst acquisition on the next incoming burst. The acquisition correlator will successfully acquire consecutive burst with spaced as close as 1.5 chips apart.

Demodulator

The demodulator module is a single VME card that provides the following functions

- PN code generation

- Signal despreading

- Phase, frequency, and time tracking

- Chip accumulation and bit detection

- Header processing to determine the burst rate of the packet

- FEC decoding

- Placed demodulated packet on the packet bus

Demodulator Controller

The demodulator controller is used to provide commands to each individual demodulator that that demodulator is the one to process the next incoming burst as determined by the activation of the burst detect line. One the demodulator is finished with the burst, it send a status message

back to the controller indicating that it is ready to receive another burst. The controller puts this demodulator back in the queue. The queuing of the demodulator cards and the assignment of next incoming burst to a specific demodulator card is performed by the demodulator controller.

Exhibit B

Name	Type	Modified	Size	Ratio	Packed	Path
white paper.doc	Microsoft Word Document	6/5/1998 9:49 AM	104,448	73%	28,321	
1 file(s)			**104,448**	**73%**	**28,321**	